DOCUMENT RESUME

ED 239 853 SE 043 764

TITLE	The Roles of Science and Technology in General and Continuing Education. Proceedings of the Conference of the Association of American Colleges (Washington, District of Columbia, December 16-18, 1979).
INSTITUTION	Association of American Colleges, Washington, D.C.
PUB DATE	[80]
NOTE	36p.; Brown ink on colored paper may effect reproducibility.
AVAILABLE FROM	Association of American Colleges, 1818 R St., N.W., Washington, DC 20009 (limited supply available from AAC).
PUB TYPE	Collected Works - Conference Proceedings (021) -- Reports - Descriptive (141)
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	*Continuing Education; Curriculum Design; *Curriculum Development; Developing Nations; Financial Support; *General Education; Higher Education; Science Education; Science Instruction; *Sciences; Technical Education; *Technology; *Technology Transfer

ABSTRACT

This conference focused on issues and topics related to the roles of science and technology in general and continuing education. The keynote address is entitled "Technology Transfer to the Third World: The Critical U.S. Challenge for the Eighties" (William Eilers). The section on perspectives on the public understanding of science includes the titles "Prolegomena" (Daniel Greenberg) and "Icarus and Daedalus" (John Clayton and Harold Hodgkinson). The section on the roles of science and technology in general education contains "What We Know and What We Need to Know" (Earl Hanson); "Science and Technology in General Education" (Anna Harrison); "On Teaching about Science" (Dorothy Nelkin); "Technical Education" (John Truxal); "A Design for a General Technology Course" (Robert Wheeler); and "Basic Science and the Liberal Arts" (Elizabeth Wood). The final section, an agenda for action, summarizes four types of continuation activities (including dissemination conferences and skills development workshops) and other measures to foster the design and implementation of new instruction in this area. The need for financial support is also briefly considered. (JN)

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THE ROLES OF SCIENCE AND TECHNOLOGY IN GENERAL AND CONTINUING EDUCATION

December 16-18, 1979
Washington, D.C.
Capital Hilton Hotel

aac

Association of American Colleges
1818 R Street, N.W., Washington, D. C. 20009

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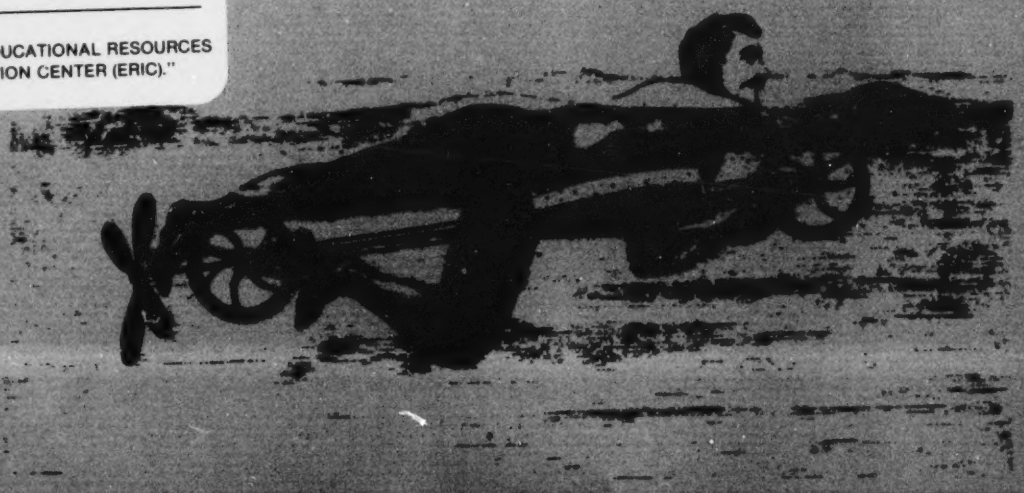

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PREFACE

The following pages represent a shadow of a conference distinct in some areas as when the airship is still on the ground and hazy in others as when airborn. In highly edited form we have tried to give the spirit of the gathering because the substance has long since gone on to other things. We have codified a bit of this substance in an Agenda for Action on the final pages.

The contents represent extensive thought by many different sorts of people. They are listed inside the back cover. To them especially we express our thanks for an extremely interesting meeting. We also are grateful for the support and insight of the Council for the Understanding of Technology in Human Affairs whose contributions enriched the conference in many ways. Finally, the generosity of the Ford Foundation made the conference possible, and the Exxon Research and Engineering Company, the Alcoa Foundation, and Deere and Company were responsible for underwriting this publication.

Regina Kyle

Edwin J. Allen, Jr.

April 11, 1980

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KEYNOTE ADDRESS

TECHNOLOGY TRANSFER TO THE THIRD WORLD:

THE CRITICAL U.S. CHALLENGE FOR THE EIGHTIES

A new profession of futurists has emerged in our society. Nowhere are they more evident than here in Washington. The more successful are invariably optimists, who proclaim that we live today in the best of all possible worlds. I am the sort of pessimist who fears that this is true.

I symphathize with the person who complained, "If I knew what I was so anxious about, I wouldn't be so anxious." For the tumultuous events of the past few weeks -- Iran then Pakistan and Libya, plus the famines in Cambodia and Somalia -- have many of us asking just where we went wrong and what we can do about our position in the world.

I think it was Paul Verly who said that, "The trouble with our time is that the future is not what it used to be." We all long for the good old days when life was not as complex. But I agree with Charles Kettering who said, "My interest is in the future because I'm going to spend the rest of my life there."

The mind boggles when one contemplates one problem piling on top of another throughout the world in such dizzying pace that we are unable to focus on any particular one of them. Yet, aside from the few who believe a nuclear holocaust is inevitable, I doubt that many of us are as cynical as the science fiction writer, Arthur C. Clarke. He observed that "this is the first age that's paid much attention to the future, which is a little ironic since we may not have one."

Your Conference Advisory Committee has shown real insight in selecting international issues in technology transfer as one subject for your program. For the decisions that will be reached in the current acrimonious North-South debate on the transfer of technology will have long-run consequences for all of us. How we share our technology, what we share, and under what terms is going to affect not only our own well-being, but is likely to

spell the difference between life and death for countless millions in the Third World during the next 20 years. I am convinced that college curriculum focusing on the role of science and technology in society must deal with the global issues.

Let me begin by mapping out, in a greatly over-simplified way, some of the grave problems confronting one-hundred twenty-two developing nations during the 80's, then suggest how their problems are intimately related to our own vital national interests and economic well-being. Then I will describe some of the significant new technologies and fields where large-scale applications have yet to be made, and finally consider a few practical ways we might go about sharing these technologies with the countries most urgently in need of our help.

What I'm going to say about the grave situation in developing countries is not new to you but it bears repeating. A quarter of the world's population - a billion people - exist in abject poverty. This poverty is so desperate that most of us have difficulty beginning to comprehend it. In South Asia alone, the numbers who live in utter deprivation are twice the U.S. population. Children suffer the most. Half of all deaths in these countries are children under five, with one out of every four never reaching that age. More than half don't attend school.

The world population growth in the next twenty years alone will equal the growth in population from the birth of Christ to 1950. Ninety percent of this growth will occur in the developing countries, adding more than five hundred million to their labor force by the turn of the century. The burgeoning population of Third World cities will suffer even greater increases which will fuel unemployment, crime, and environmental stress.

Compounding these problems are the immediate crises of increasing energy costs, rising external debt, and the threat of recession in the industrial countries. The slowdown in our economy means that imports from developing countries will probably sharply contract, further restricting their ability to import goods and repay foreign loans. Many developing nations have few resources and fewer technical personnel. Fifteen of the thirty least developed are totally landlocked. Most are in the tropics, where they are plagued with diseases such as river blindness and snail fever, a new upsurge of malaria, spreading deserts, tsetse flies, locust plagues, monsoons, and earthquakes.

The specter of starvation already confronts Cambodia. One third of East Timor's population is malnourished to a dangerous and probably irreversible point. The world's largest refugee population, in Somalia, faces the spread of disease and starvation. India has suffered major crop failures this year. Zambia's disastrous corn crop may be only another harbinger of more serious and widespread famine we may likely see in the eighties.

Significant international steps are being taken to cope with global problems. The World Food Council in Rome monitors the situation, seeking coordinated solutions. The International Fund for Agricultural Development aids the poorest farmers. But when you are on the brink and your

numbers are 1.3 billion, not to deteriorate further and go under is a vast undertaking in itself. This is one reason funds for programs in food and nutrition continue to receive the lion's share of nearly all donor bilateral aid.

Traditionally, we have justified development assistance on humanitarian grounds, or sometimes arguing that economic aid is vital to national security. But now there is a growing perception that the developing countries have become absolutely essential to the health and growth of the American economy. Our economic well-being depends to an ever-increasing extent upon our ties with the Third World, links that are growing faster than with any other group of nations.

Export promotion has become far more significant -- a major policy instrument to promote growth and strengthen the faltering dollar. We export more to the developing countries than to Western Europe and Japan combined. About thirty-five percent of our total exports go to the developing states. A third of our wheat, cotton and rice is sold to these countries, and our twelve fastest growing markets are all developing countries. Our sales in recent years are growing 50% faster to developing countries than to industrial nations.

These less developed nations are also the source of valuable imports. Last year the U.S. bought nearly $75 billion dollars or 42% of our total imports from them. We rely heavily on them for many commodities critical to industry -- 30% of all raw materials are derived from this source. It is estimated that almost half of the unexplored global deposits of gas and oil lie in non-OPEC developing countries. They offer potentially diversified sources of supply for all oil-importing countries.

Last year U.S. firms invested over $40 billion dollars in developing countries, a quarter of our total foreign direct investment. And the rate of return on investment in these countries last year was 66% greater than the rate for investments in developed countries. They proved highly profitable, and last year generated 35% of total income from U.S. foreign investments. And during a time when we are facing massive unemployment from the shutdown of major industries and their suppliers, we should keep in mind that the jobs of 1.2 million American workers depend on exports to developing countries. We all know that one of the most strident and pressing demands from the developing countries is that we share our technology with them and help them build their own capacity both to adapt foreign technology to our needs and to generate their own appropriate technologies. But does modern technology possess such potential?

History reveals just how terribly wrong scholars, scientists, politicians and the media have been about the future of science and technology. In 1901 Senator Simon Cameron said, reminiscent of present attitudes on the Hill, that "I am tired of this thing called science. We have spent millions on it for the last few years and it is time it should

be stopped." Regarding early flight, the New York Times wrote two years later, "We hope Professor Langley will not put his substantial greatness as a scientist in further peril by continuing to waste his time and the money involved in further airship experiments." And in 1945 Admiral Leahy told President Truman that the atomic bomb "was the biggest fool thing we have ever done. The bomb will never go off," he said "and I speak as an expert on explosives."

In any event, it is inevitable that the sceptics notwithstanding new technology will pervade our lives in the 80's. The greater potential of the new technology lies in relatively new fields where large-scale applications have yet to be made. The emphasis will be on doing more with less in a climate of dwindling resources. We all hope that the auto makers are right when they predict that minicomputers in cars may reduce gasoline consumption by at least 15%.

For the most part new technologies will fall into five rapidly emerging fields -- microprocessors, fiber optics, superconductivity, space technology and recombinant DNA. So far as developing countries are concerned, there are a number of more promising fields of technology we are convinced will come into their own during the next ten years. I would like to review a few of the more exciting technological advances with you.

Let's look at microprocessors. Within five years we'll be able to put 256,000 bits of information on a single silicon chip at no increase in price, whereas just 10 years ago only 16 bits could be fitted onto one chip. By 1990 portable microcomputers will be almost as commonplace as handheld calculators are now. This means that many of the functions now performed by human beings in the manufacturing and service sector of industrial economies can be done faster and cheaper by microelectronic devices or by robots controlled by these solid state instruments. This means speed, cost reduction, flexibility, reliability, and capacity for self-diagnosis and correction. One forecast is that while the French banking industry will expand measurably during the 1980's employment will decline 30%. Since the occupations involving information now constitute the largest category in the work force of most industrial countries, even moderate increases could have a devastating impact on employment.

The Science Policy Research Unit at the University of Sussex believes that job displacement will draw far ahead of job-generating investment in the 1980's. In Third World countries already confronted with high unemployment -- in Iran it is running 25% -- there are likely to be large-scale social crises when they are forced to deal with a rapidly growing work force, widespread poverty and a badly skewed income distribution.

Recombinant DNA holds great promise. We now produce insulin in this country with a new DNA process and hope we can adapt a similar process to produce interferon, a tremendously expensive and little studied substance

that could offer a new approach to fighting cancer. Scientists are growing a special type of bacteria which has an enormous appetite to gobble up massive oil spills from supertankers. In Saudi Arabia Chinese scientists are working to manufacture a protein-rich single-celled form that can be grown on a petroleum substrate for animal feed.

We will see impressive new advances in the food field. The Agency for International Development (AID), for example, is investing $40 million to improve selected grain legumes which make up the major source of protein for half the world's poor. Recent breakthroughs in the science of biological nitrogen fixation offer considerable promise in increasing the yields of certain legumes such as cowpeas and soybeans.

The Agency is also working on new crop introductions such as the winged bean. This tropical legume has a protein content about identical to that of the soybean. The U.S. National Academy of Sciences has identified dozens of little known or underutilized tropical crops that it believes have a great untapped potential for developing countries, many of which make less demands on soil, water, and fertilizer than temperate crops previously introduced in these regions.

Many new fishery advances have been made in recent years. The most widely cultured fish in Southeast Asia, the milkfish, can now be grown inexpensively in the millions of hectares of unused mangrove swamps and brackish coastal lowlands.

Auburn University fishbreeders have produced a new hybrid tilapia which has a significant worldwide potential. Brazilian scientists recently discovered a herbivorous Amazon fish that will convert agricultural and food industry wastes to edible protein.

The critical global shortage of firewood and the massive destruction of tropical forests in the greenbelt around the equator is being attacked from many angles. One partial remedy promoted by AID experts is the introduction of an extremely fast-growing tree from the Philippines called the leucaena. It can grow 65 feet and 16 inches in diameter within five years. Its wood can be used for pulp, building houses, firewood or charcoal. In addition, its leaves provide a cattle feed rich in protein or can serve as nitrogen fertilizer. The seed pods can be eaten or ground into flour. The gum from leucaena can be used as a thickener for foods like ice cream and mayonnaise or for cosmetics. In some areas mimosine found in its leaves causes animals to lose hair. One Australian sheep rancher turned this to his advantage when he fed forage to his sheep for 10 days and was able to remove their wool with a stroke of the hand, making shearing unnecessary.

There are other answers to the firewood shortage. The simple lorena stove developed in Latin America and made of clay and sand uses firewood much more efficiently. Biogas digesters are supplying methane for cooking in India and many other countries. Solar reflectors are increasingly adopted for cooking in many tropical areas.

What is the ultimate answer in providing village energy needs in developing countries? Dr. I. H. Usmani, the UNDP's energy adviser, is convinced that it lies in photovoltaic arrays which use small silicon solar cells to convert sunlight directly into electricity for storage in local village batteries. Last year the cost per peak watt was around $7, but this is expected to drop to about 50¢ a peak watt by 1986, only six years from now. At this level it can compete economically with oil and possibly other fossil fuels. Right now one village in Upper Volta is using the photovoltaic source to pump water and grind grain with practically no upkeep cost. There are problems of course -- the source of raw materials is limited and battery storage often presents a problem.

The use of small scale hydroelectric power is another very promising possibility for villages. For example, fifteen thousand dollars and a lot of labor permitted several villages in a remove valley of Papua New Guinea to install a mini-hydroelectric plant. For the first time villagers not only have light for their schools and a regular water supply but also daily hot showers.

Rolls Royce has just developed an inexpensive, small-sized turbine which can generage electric power for rural areas using a low-grade alcohol as fuel. They are actively promoting distilleries to convert cassava, sugar cane, and agricultural wastes to alcohol in developing countries that are suffering most from escalating oil prices. And in Brazil, two million cars are now fueled with gasohol which uses a mix of local alcohol distilled from sugar cane.

A host of other intriguing technologies hold a promising potential for the 80's. For example, the scientist who developed the concept for towing icebergs from Antartica to supply Saudi Arabia with fresh water was in the office last Friday. He has a new scheme. It involves a giant sausage-like steel skin about 2/3 of a mile long which is pulled underwater by an ocean-going tugboat that is also semi-submerged and has a propeller over 100 feel in diameter. He feels the first high priority application of this new approach would be in Chile. There, the giant Kennecot and Anaconda copper companies are desperately short of fresh water for copper beneficiation near the Atacama desert, one of the dryest places in the world. He proposes to tow fresh water from the abundant supplies in the Southern Chile rivers not only to help the copper companies, but to make the Atacama bloom.

Negotiations are underway in the UN Conference on Trade and Development -- UNCTAD -- regarding codes of conduct governing technology transfer and multinational sharing of technology assets. Elsewhere negotiations continue on revising the Paris Convention which governs international patents and licensing agreements. This debate on mandatory versus voluntary codes comes down to the question of the extent to which industrial countries are prepared to subsidize technology flows competitive with their own industries. In our own country corporations and unions are joined in arguing vehemently that export of technology means export of jobs, pointing to our experience in recent years with Korea, Hong Kong, Taiwan, Singapore and other recently industrial nations.

In any event we should enhance the negotiating capability of developing countries in their effort to acquire foreign technology. One practical way has been suggested by the National Association of Licensing Executives which has asked AID to help them in conducting training courses for developing country executives responsible for negotiating foreign technology license agreements. This is a positive step in the right direction.

It is essential that we strengthen indigenous capabilities in these countries to decide among technological alternatives and to help them pursue their implementation. Special measures must be adopted to facilitate the international flow of technology for the benefit of least developed countries. There is little opposition in this country and among other donor countries when we talk about transferring technologies in agriculture, nutrition, health, population and education. All agree on the humanitarian aims of such transfers, and we find strong support for these activities.

The argument begins at the request for high technology which will enable more effective competition in international markets. Naturally, the multinationals will not give away this technology or offer it for concessionary reduced license fees. All have invested heavily in R&D which represents company assets just as plant and equipment do. Fortunately, there are many other ways to get at this problem short of resuming the bitter North-South confrontation of the early 70's.

For example, Korea, Taiwan and Singapore attribute much of their industrialization success to the technology brought back by thousands of returned students who returned with engineering and business skills from study abroad. Other countries can tap this same source. In fact, Turkey has been highly successful in an experimental UNDP program which provides for the travel and living expenses of Turkish expatriates who return for short periods to share technology they have developed in living abroad. AID hopes to replicate this experience together with UNDP in a number of other developing countries.

One final comment. At the UNCSTD Conference in Vienna, there was agreement among all donor countries and the Group of 77 that we should launch a new global effort to develop technological capabilities in the least developed countries. A modest new two-year fund of $250 million dollars was agreed upon for this purpose, an activity to be run by the UNDP. There are firm pledges from most of the European donor nations and hopes for substantial contribution from OPEC oil countries. Yet, with our own budget stringency, there seems to be some questions of whether the U.S. can come up with its fair share contribution. The UNDP has an outstanding record of advancing the cause of development, and it is particularly effective in technology. I hope that sober and thoughtful heads will prevail in Congress and recognize the value of this proposed new UN activity.

Forgive me for rambling on for so long. One last remark if you'll permit me. I won't be able to face my colleagues in basic research without a brief word on their behalf. Alfred North Whitehead said that scientists are animated by the purpose of proving that they are purposeless. Werner von Braun defined basic research as, "what I am doing when I don't know what I am doing." I did a radio interview with Dr. von Braun shortly before he died. He told me that he was absolutely convinced that man would be supporting space colonies within our lifetime even though most of us still consider this pretty far out. We must of course wait and see if his great vision proves correct.

And speaking of far out, let me close with an ode to basic science and that most far-out of all things, the elusive PULSAR. It seems appropriate in this Christmas season.

Twinkle, twinkle pulsing star

Newest puzzle from afar

Beeping on and on you sing--

Are you saying anything?

Twinkle, twinkle more pulsar

How I wonder what you are.

William Eilers

PERSPECTIVES ON THE PUBLIC UNDERSTANDING OF SCIENCE

PROLEGOMENA

One difficulty of covering science policy in Washington is not that information is hard to come by; rather, the difficulty is that there is a deluge of it. Everyone wants to get into the papers or on TV, because it's now taken for granted that getting noticed by the press is an important element in winning your way in the public process.

One hears a lot about investigative reporting, and, of course a great deal of it is of very high quality. But one of the most essential ingredients in investigative reporting is an aggrieved bureaucrat who wants to spill the beans. Usually this person has lost out in some organizational struggle, and turns to the press as a court of last resort.

When it comes to science reporting, the press does a mixed job, whether in dealing with the substance of science (what's going on in the lab) or with science policy (what's going on in the committee rooms that dictates policy and provides money for the lab.). Variability in this reporting is enormous. Most news organizations do a fairly good job of covering presidential and legislative matters, sports, local affairs, and so forth. But science remains a subject with which the press is not comfortable. It comes as a surprise to many scientists who sincerely feel that news of their work should rank high in journalistic priorities that science reporting is second-class stuff in most news organizations. Science reports rarely qualify for top space or time in the media, and science writing, with a few exceptions, has not proven to be a promising route for climbing the executive ladder.

The scientific community itself bears some responsibility for this state of affairs, if only by omission. Scientists, when dissatisfied with the quantity or quality of science reporting, tend to respond by sulking, by taking the position that next time, they'll refuse to have anything to do with the press. I've been told of this response so often by scientists who feel the press has performed poorly. It is not merely a rare or occasional response. In responding in this fashion, I think scientists fail to recognize that the better news organizations i.e., the major papers, the news weeklies, and network TV are highly sensitive about what informed people think of their performance. But not often will scientists take advantage of this sensitivity to make an effective complaint. Scientists,

for example, will complain of the inadequacy of science reporting, but not often will they go to a specific news organization and say that you goofed by ignoring a monumentally important scientific report in Nature or Science last week.

The subject of science reporting is particularly appropriate at this time because we're enjoying a proliferation of science journals aimed at the general public. The New York Times has a weekly science section, the AAAS has successfully launched Science80, Omni magazine got off to a fast start last year and is doing extremely well, CBS is planning a series of half-hour science shows, and various other new science journals are in the works.

This publishing boom offers the scientific community an unprecedented opportunity to make its work known to the public -- in a timely and reliable fashion. If scientists are concerned about public attitudes toward science and public understanding of the substance of science, as so many say they are then the reasonable course is to get out there and use this booming interest in science as a means for reaching the public.

Daniel Greenberg

ICARUS AND DAEDALUS

The subject is science and technology and what the public perceives or understands that to mean.

I would guess that a great many people believe that science will provide them with what they want, and technology will provide them with what they need. Science won't give us what we want; it will give us what we need - the truth. And the truth may not be what we want at all. It may be bad news. But if it's science - I repeat, if it is science - then it will be our best shot at the truth. Good, bad, or indifferent, we need to know that. Even if we don't want to.

As for technology? Not what we need, friends; technology gives us what we want. That's why Huxley said, "Ends are ape chosen; only the means are man's." Think about it. Ends, the products, those are chosen by animal desire. How we achieve those - fantastic! Television? A miracle in space - for the Gong Show. Technology gives us what we want.

Is that the difference between science and technology? No, not exactly. Science - I'm sure you scientists here need a humanist to tell you this - science is a product of curiosity and the freedom to pursue it. It requires

no other definition, no other justification. It is not, by the way, a method. It is an attitude. And technology is not a product. It is not an airplane, or a television set, or a can opener. It is a method, a process. It is a result of desire and systematic behavior. Invented by apes.

> You all know the experiment. You put the chimp in the cage with the bananas out of reach and a group of tapered, hollow wands in the cage. He's hungry. He tries for the food. Can't make it. Tries with a stick. Too short. Gets frustrated. Screams at his wife. Or his keeper. May be the same. Keeps messing around with the damned sticks. Finally figures out that if you join them together, you can snag the bananas. Bingo! Technology.
>
> Objective: bananas.
> Problem: out of reach.
> Resources: arms, sticks.
> Procedure: survey resources, devise plan.
> Test plan: first plan fails. Revise plan. Second plan fails. Revise plan. Third plan succeeds.
> Technology.
> But not science.
>
> Science begins when the monkey wants to see what's underneath the floor of the cage. And the keeper lets him.

My thesis is that the public has been conditioned to rely upon faith. That reliance, I believe, is dangerous and probably fatal. We have been conditioned to rely upon faith for thousands of years, because we had no information as to the true nature of the physical world or of ourselves. When you have to move forward in ignorance, faith is a survival technique. It is absolutely necessary. We are conditioned to choose faith. But having faith in science is <u>not</u> the same as understanding science.

Science and technology are related insofar as they both imply rational systems, thought, intelligence. They are different from faith in that faith implies committment to the unknown and the unknowable; emotion, not reason; hope, not evidence; chance, not certainty. In 1957, physicist J.H. Rush wrote, "The crisis of life on earth is not the threat of atomic catastrophe. That is only its most acute and obvious symptom. The crisis is the emergency of intelligence, and its intervention in the course of evolution. When man repudiated his natural environment, he embarked on a course that leaves no choice ultimately between controlling almost everything or abandoning intelligent control entirely.

We have no choice. We must use our intelligence or we will die. And what is this intelligence we must use? Rush concludes, "Intelligence is not power in the sense that an avalanche or a lighting bolt is power. Like

organism, it is an ordering influence. Intelligent order implies purpose, and purpose grows out of the freedom to choose among imaginable alternatives. Every coercive restriction on man's freedom to imagine and to test his conclusions in action, every choice that is precluded by social edict, is a loss of freedom and to that extent a loss of power. The direction we must go is clear. It is the direction of freedom from social coercion, and freedom from the emotional distortions that make such coercion necessary. To perfect his power, to realize himself to the fullest, man must perfect his freedom."

Nineteen years ago, almost to the day, C.P. Snow appeared to refute this thesis, at least with respect to the relationship between freedom and science while delivering a series of lectures at Harvard University. "In more liberal days," he said, "in the days of Rutherford's Cambridge, Bohr's Copenhagen, Franck's Gottingen, scientists tended to assume, as an optimistic act of faith, as something which ought to be true because it made life sweeter, that science could only flourish in the free air.

"I wish it were so," Snow continued. "I think everyone who has ever witnessed secret science and secret choices wishes it were so. But nearly all the evidence is dead against it. ...Scientists have worked, apparently happily, and certainly effectively, in conditions which would have been thought the negation of science by the great free-minded practitioners. But the secret, the closed, the climate which to earlier scientists would have been morally intolerable, soon became easy to tolerate. I even doubt whether, if one could compare the rate of advance in one of the secret sciences with one of those which is still open to the world, there would be any significant difference. It is," Snow concluded, "a pity."

Well, it probably is. But it is not, I think, a rejection of Rush's thesis that freedom is a condition for the development of science. Snow is talking not so much about freedom as he is about secrecy, which, while related, is not the same. The essential freedom is freedom from social, cultural, and religious orthodoxies that prohibit our asking questions, seeking evidence, determining the facts. And I believe Professor Rush is correct, the emergency of intelligence upon the planet has left us with no recourse but to use it well.

More and more, many of us are not going to like the harsh realities of the tunnel that science is showing us. And the cry will be, "Close your eyes! Don't look! It's too dangerous!" And with them, the cries that to challenge ignorant opinion as long as it wears the mantle of respectability is to be guilty of bigotry, predjudice, or intolerance. It is not popular science. And too many scientists are comforted by a public faith in science and technology. For now so many believe that science and technology will save us. Don't worry about over population, energy shortages, pollution, the future - science will save us all!

A public conditioned to have faith, now has a new priesthood: science and technology. Beautiful! But faith in a science and technology that solves all problems is no more rational than faith in the Ayatollah

or the Virgin Mary. It simply means that we believe that somehow, someone will make it all okay.

Do you remember why Prometheus was chained to the rock? No, not for stealing fire. Nor according to Aeschylus. Fire was a secondary sin. The crime of Prometheus was that he took from men the fear of death. "That was a great gift," the chorus chants in wonder. "How did you accomplish that?"

"I gave them," Prometheus replies, "blind hope." Faith.

We must have hope. That much is true. Science may tell us the nature of the tunnel - and we may not like what it looks like at all!

But science will not solve our problems. It will simply show us what we have to work with. And, with that knowledge, it will be our opportunity to choose and to create our future. In the beginning, of course, God created. Now, it is our turn. Blasphemy? Well, that's what the scribes and the pharisees thought, all right. "How can you, a man, claim to be God?" they challenged.

"Is it not written," Jesus replied, "that all men are gods?" Strange - I've never heard a preacher use that text. They much prefer Paul. He pushed faith. Jesus pushed science and technology. Remember when he was accused of having done something of redeeming social value on the Sabbath, and nothing was supposed to be done on the Sabbath?

"The Sabbath," said Jesus, "was made for man. Not man for the Sabbath." Now that's a technologist.

No, we are not the new priesthood. We should decline the nomination. We're just part of the public. But if we remain silent, the public will not prosper from our silence. And if we continue to allow - as we have - technology to be the servant of a blind faith in a future governed by ignorance and appetite, we will indeed demonstrate that we can be fruitful and that we can multiply, but we will not be able to replenish the earth. Let science enable us to see. And then?

Why then, each of us will have to choose the path that we shall follow, in the light of what we have seen. And when that choice becomes based upon the truth as to the nature of our universe and our condition, why then, perhaps, we humanists may have a suggestion about the path that we should follow. But that, of course, is a topic for a different discussion.

John Clayton

. . .

There are two main points to the comments I would like to make today. The first is that people are already using science in a remarkable variety of settings in everyday life, if one is willing to accept a Baconian definition of science. The second major point is that many institutions are already teaching science to a variety of adults in a variety of settings, and that colleges and universities are only a small part of this new total.

On the first point, it is amazing to see how rapidly we have moved into a world-wide network of very sophisticated distance learning centers. (These are universities whose students may be many miles away.) In addition, it seems to me, large numbers of people have come to revere technological objects as symbols of science in action. Marshall McLuhan made the marvelous observation that every piece of obsolete technology becomes an art form. One has only to look at a group of grown men admiring and touching a steam locomotive to realize the truth of this observation. No one knows quite what to do with this basic fact of human existence, but it may represent a new "liberal art."

In addition, our everyday lives include many examples of scientific methods in action in the area I call social technology. This includes polls, delphi surveys, planning techniques, the training industry, the use of social indicators, prediction and forecasting, quality control, productivity measures, gaming and simulations, social and economic audits, double-entry bookkeeping. These seem to me to be examples of explicit forms of science and technology applied to social areas.

We also have discovered in the social sciences, the basic truth of the Heisenberg principle, "There is no neutral social science; there is no test that does not influence the mind of the test taker. To sample, therefore, is to change or distort." A brief look at planning should make the point. It used to be fun to plan things because one could basically pick a trend and ride it. However, since 1973 or thereabouts, the number of variables has increased and the number of constants has declined rapidly. Along with this has gone a change from measures of the quantity of growth to measures of quality of growth. This seems to apply to businesses as well as to social organizations generally. In addition, planning is difficult because of the ambiguities in the American social systems that makes Sweeney's law far more prevalent and important. As Americans, we find it difficult to believe that technical solutions to problems create more problems than they solve.

"Success" of the Technological Era	Resulting Problems of Being "Too Successful"
* Prolonging the life span	* Overpopulation; problems of the aged
* Weapons for national defense	* Hazard of mass destruction through nuclear and biological weapons
* Machine replacement of manual and routine labor	* Exacerbated unemployment
* Advances in communication and transportation	* Urbanization; "shrinking world"; vulnerability of a complex society to breakdown (natural or deliberate)
* Efficiency	* Dehumanization of the world of work
* Growth in the power of systemized knowledge	* Threats to privacy and freedoms (e.g., surveillance technology, "bio-engineering"); "knowledge barrier" to underclass
* Affluence	* Increased per capita environmental impact, pollution, energy shortage
* Satisfaction of basic needs; ascendance up the "need-legal hierarchy"	* Worldwide revolutions of "rising expectations"; rebellion against "non-meaningful work"; unrest among affluent students
* Expanded power of human choice	* Management breakdown as regards control of consequences of technological applications
* Expanded wealth of developed nations	* Instrinsically increasing gap between have and have-not nations
* Development of prepotent high-technology capability	* Apparent economic necessity of continuous war to use up the output of the "megamachine"

As a final example of the difficulties of planning and Murphy's law, it now appears that given four kinds of effectiveness at work in the economic sphere, it is impossible to achieve all four simultaneously:

I. Economic -- turning out students with skills needed in labor force. (manpower plans).

II. Technological - efficient use of resources, little waste. (production economies).

III. Fiscal - minimizing taxes while meeting social goals. (discretionary income good).

IV. Social - reducing inequities based on family, class, race, sex.

(Benson and Hodgkinson, Implementing the Learning Society, Josey-Bass, 1974).

My second major point is that many people are teaching science who are not in colleges and universities. This new function is related in part to institutional mission which is becoming much more egalitarian and broadly based. Far more people are staying in schools and colleges longer, and colleges are getting more diverse by race and sex. But in addition to these things, it is important to know that there are approximately 11,500,000 students being educated in colleges and universities while 17,000,000 Americans, according to the National Center for Educational Statistics, and 46,000,000, according to the College Entrance Board, are being educated somewhere else.

WHO IS LEARNING WHAT? WHERE?

Agricultural Extension	12.0 Million
Community Organizations	7.4 "
Business and Industry	5.8 "
Professional Associations	5.5 "
Part-time College	5.3 "
City Recreation	5.0 "
Churches, Synagogues	3.3 "
College and University Extension	3.3 "
Government Services	3.1 "
Public School Adult Programs	1.8 "
Federal Manpower Programs	1.7 "
Armed Forces	1.5 "
Graduate and Professional	1.5 "
Trade Unions	.6 "
Community Education	.5 "
Free Universities	.2 "
Total	58.4 Million
In Schools	12.4 Million
Non-School Settings	46.0 Million

College Board, New Directions for a Learning Society, 1978

An awful lot of science is being taught to people in these new settings. Particularly if one thinks of organizations like AT&T with their budget for educational service of over eight hundred million dollars. (Incidentally, the latest testimony gives the education budget for AT&T at 1.2 billion dollars.) New laws on continuing education are making millions of Americans return for more professional education, but not necessarily with a college as the service provider. If we look at all of the new players in the post-secondary education game and think seriously about which ones of these are teaching science, it is quite important for this conference to realize the large number of other institutions in American life that are involved with teaching science to Americans in a remarkable variety of walks of life.

So to sum up, it seems to be obvious that Americans know technology well, and that they usually understand the science which made the technology possible. It is through an analysis of planning as a strategic activity that we begin to see the weaknesses in linear scientific method in the social area. And finally, it is important to realize that science is being taught to millions of American adults by faculty members who are not part of any college or any university, but may work for the military, a corporation, or any one of thousands of organizations in American life.

The key implication of this, of course, is that science is far more important than most scientists will let on. We need to find some ways of communication across these various institutions that now are responsible for bringing science to Americans whatever their age or location.

Harold Hodgkinson

THE ROLES OF SCIENCE AND TECHNOLOGY IN GENERAL EDUCATION

WHAT WE KNOW AND WHAT WE NEED TO KNOW

Deeper knowledge of the conditions for life on this earth and a common dedication to make this life as fulfilling as possible are obvious challenges that lie immediately ahead of us. Those challenges are especially compelling for liberal education, not only because of its perennial concern for the development of the individual in relation to society, but because of a growing sense -- national and global -- of crisis. One expression of that crisis, and it seems unique to our times, is the incongruence between what we know and what we need to know. For example, we have never before known so much about our environment and its resources and ecosystems, yet we continue to wreak mayhem on them. We have never before known so much about human society and its institutions, yet we cling to chauvinistic social aspirations and profligate lifestyles that are demonstrably destructive of many of our cherished values. We have never before known so much regarding the human psyche and the individual's emotional, aesthetic and intellectual needs, yet we continue to thwart the legitimate aims and personal fulfillment of women, of racial and ethnic minorities, and of ourselves as individuals.

To repeat, we must better understand the conditions of our lives and find a deeper dedication to making those lives worthwhile. The role of scientific knowledge is integral and, hence, essential to these efforts. Such knowledge subsumes a publicly available methodology for describing and analyzing the conditions of life; it contributes a common foundation of information from which to build our responses to what we need to know; and in recognizing its own limitations and its tradition of open exploration and self-correction it can be a flexible and adaptable resource on which to depend in facing the challenges that lie ahead.

Earl Hanson

SCIENCE AND TECHNOLOGY IN GENERAL EDUCATION

What are the goals of education in science for the general student, those students who do not have and probably will not have professional goals that require technical competence in science. I have endeavored to develop a first course in chemistry at the college level for these general students and my nominations for the primary goals for such courses are that students be able to:

1) understand scientific phenomena,

2) extend their own knowledge of things scientific,

3) derive self-satisfaction in learning about scientific things, and

4) continue to develop their knowledge and critical interpretation of the mass media for the rest of their lives - a period of perhaps half a century.

Note that none of these goals are testable in the usual sense of testing.

Along the way, the student learns a lot about chemical, physical, and biological phenomena. Just exactly what phenonemon is studied does not seem to me to be so very important. It is, however, important that they develop some interest in and sense of how empirical knowledge is acquired, how models are constructed, and how models are tested. Note the choice of the words 'develop some interest in and sense of'. There is no hurry to rush into a detailed analysis of the methods of the natural sciences. To analyze the methods of the natural sciences requires a maturity these students have yet to develop. It is also important that they develop some interest in and sense of the powers and the limitations of scientific studies and technological processes.

Once the concept of developing a course for students who do not need to acquire technical competences in order to go on has been accepted, there is tremendous freedom in the selection of the methods of approach and the specific topics to be included. The primary limitations become the creative capabilities of the instructor. I am convinced that there is no shortage of creative scientists willing to use their talents and energies to develop programs rewarding to the general student.

Our concern today is the understanding of the relation of science and technology to society and the concern arises from the fact that in a democratic society, the value judgments made by the public through their

surrogates (elected officials and appointees of those elected officials) determine 1) the development of science and technology and 2) the use of technicological options made possible by scientists and technologists. The decisions made by the public will be instrumental in the determination of the quality of life, including the quality of the environment and the availability of both renewable and non-renewable resources, for current and future generations. The value judgments made by the public can be no better than the capacity of the public to understand both the positive and negative impacts on society of the available options created through the use of science and technology by the technological community. The capacity of the public to understand the potential impacts of each option can be no better than the capacity of the scientists and technologists to identify the potential benefits and the potential costs (risks) associated with each option.

But many scientists and technologists do not understand the relation of their professions to society and educational institutions may be doing very little to help their students or their faculties in science and engineering to understand the social, economic and political matrix within which their professions are embedded. To provide meaningful education in science for the general student requires a college or university administration not only to express such a commitment but also to implement it through hiring practices, promotion practices, tenure criteria and the provision of facilities and supplies. Many individuals who are strongly committed to the extension of scientific knowledge and the production of highly competent scientists and engineers view a commitment to the education in science of the general student as a diversion of resources from research and scholarship and the route to declining productivity and status for the institution.

It is extremely difficult to bring about changes of attitudes within educational institutions - particularly if these changes in attitude are viewed as a threat to that which you have committed your professional life. I viewed this as the most serious obstacle to the attainment of the goals being discussed here. To make sustained progress, however, there must be prestige accorded to those who utilize their talents and their energies to provide dynamic education in science for the general student.

Anna Harrison

ON TEACHING ABOUT SCIENCE

While much discussion at this conference has focused on teaching science and technology to non-scientists, I would like to make a case for teaching about science. The case, in fact, is well established. There are in the U.S., according to count in 1977, at least 2300 science, technology and society courses in some 400 institutions in the U.S. STS programs are also proliferating in Western Europe: the British SISCON (Science in a Social Context) group, a Dutch chemistry and society program, a French Science, Technologie et Societe program, and so on. These courses are sustained by a concern about the pervasive role of science in contemporary life - the effect of advances in science and technology on nearly every aspect of human experience - from industrial development and work to religious beliefs. Some are theoretically oriented, seeking to enhance understanding of an important social process. Others have more activist goals, motivated by the hope that changes in higher education will lead to social change, producing scientists who are more responsible and aware of their social role, and enhancing the capacity of future citizens to better influence the forces that affect their lives. All reflect an effort to compensate for what is felt to be a major gap in higher education.

Why have so many issues that scientists have long regarded as technical become so politicized. A variety of explanations have been offered to account for various disputes:

* Controversies, claim some people, are simply parochial protests against decisions that affect particular interests, another manifestation of interest group politics.

* Disputes, claim others, reflect traditional antiscience sentiments.

* Objections to science and technology reflect insufficient knowledge, and the uncertainty about questions of risk.

* Or, it is most often believed, science is a problem only because people are poorly informed.

Each of these explanations has some validity. But it seems to me that the persistence of conflict in so many areas of science and technology calls for a different level of interpretation.

Systematic study of disputes suggests that we are witnessing an important shift in the public perception of science as a source of legitimacy and an authoritative standard of rational decision-making. Scientific

standards have long had a universalistic appeal as a widely accepted basis of consensus on many policy questions. There has been a special affinity between the norms of science and the liberal democratic image of politics that has given science special force as a model of decision-making based on rational standards. Less blemished than other spheres of activity by factional or personal factors, science has played a special role in public affairs.

However, the social problems associated with technology and awareness of factions and interests within the scientific community have eroded this image. Science is increasingly perceived less as a source of consensus than as a political resource exploited to justify special claims. Environmentalists hire their own experts as the only effective way to challenge controversial technologies. Laetrile users have experts to argue the efficacy of apricot pits. Even fundamentalists seeking to have Genesis taught in public school use scientists to prove that creation theory is a scientific alternative to evolution theory. Despite the obvious value issues underlying such disputes, science has been engaged as a source of power and influence. This has in many ways benefitted the technical community--creating employment in a variety of new advisory and consulting roles (the dispute over Three Mile Island has brought some $10 million in consulting opportunities). However, it has its costs. Science is perceived as a "problem" not only in its immediate impact but in its political role, and controversies can be interpreted as negotiations over the appropriate relationship between science and the polity. Indeed, pervading very diverse disputes--over nuclear power, recombinant DNA, over chemical carcinogens, saccharin, or laetrile--is the question of "who should control crucial policy choices." Accusations of secrecy, suppression of information, and manipulation by experts are ubiquitous. For these disputes are less against science and technology than against the power relationships associated with them; less against specific technologies than the declining control of citizens over policies that affect their interests; less against science than the use of scientific knowledge to mask political choice.

In conclusion, science education should include analysis of science and technology less as autonomous activities than as social and political institutions. This requires a far more critical approach than many scientists feel comfortable with. Indeed the broad implications that I have discussed are often of interest primarily to critics. And as economic priorities, energy problems, and medical needs create powerful pressures for technological advance, the less immediate and often vague social implications of technology tend to be dismissed. Science and technology, however, are but a bunch of possibilities; their direction reflects value choices and power relationships. To teach students to look seriously at the way these choices are made is to maintain confidence in our capacity consciously to influence these directions and to prevent disasters that often appear in retrospect as the unalterable results of iron laws.

Dorothy Nelkin

TECHNOLOGY EDUCATION

At this conference we must avoid the usual fate of such meetings: enthusiastic concensus on the part of all attendees, then no follow-up action except possibly at the home colleges of two or three participants. If we truly agree on the importance of education in science and technology literacy for all college students, we can create a model for the problem we face. There are perhaps 3000 colleges which need such a course; if each of the 100 of us accepts responsibility for 30 colleges, our next meeting two years hence will be able to focus on analysis of the success stories.

Certainly over these two days we have discussed the problem defined over a wide range of:

Audiences (characteristics of the students)

Modes of educational delivery

Specific course goals and objectives

From these discussions, and from my limited background as an engineer, I believe one strong conclusion can be drawn.

There is a pressing need for courses on modern technology (i.e., applied science and engineering) for all undergraduate students. These are courses designed to present:

(1) Characteristics, limitations, and capabilities of modern technology

(2) Ways of thinking and problem-solving of the engineer.

Such offerings by applied scientists and engineers are an important element of a broad, liberal education, an essential step in preparing the student to live in a technological environment and to participate actively in the social and political process controlling the development of the technology.

I should emphasize that I am speaking now of engineering (or applied science) courses. Such courses are important to complement the important offerings by faculty in the humanities and social sciences. At my own university, as at many other colleges, the students can take courses in

Philosophy of technology

History of technology

Literature and technology

Economics and environment

Sociology and technological systems

Furthermore, we have the usual courses on physics and mathematics for poets--offerings which start and remain at a low level, focusing on basic scientific concepts.

Such an array of courses constitutes an important element of a liberal education. Unless there are parallel courses offered by applied scientists or engineers, however, the students usually do not have an opportunity to come in contact with the way the engineer thinks about socio-technological issues. For example, whether technological or social determinism fixes change in our society is a fundamental question, but certainly equally important is the problem of controlling that change in the coming decades so that we decrease the differences between the economically disadvantaged and the majority of our society. With engineers filling over 50% of the decision-making positions in the federal government, understanding of the engineer's way of approaching problems is an essential element in education for participation in the political process.

To illustrate the type of courses I believe are important in terms of the goals of the college educational system, I will describe briefly two specific examples.

CAFE standards

The corporate average fleet efficiency (CAFE) requirements on auto manufacturers demand 27.5 miles/gallon by 1985 in a specified, year-by-year improvement. Is this requirement, which is causing U.S. companies so many problems, necessary and desirable? Should this be followed by 50 (or 40) mpg in the 1990's?

When the engineer looks at a problem such as energy conservation in auto driving, he tends to break the study into five parts:

(1) Is it a significant problem? In this case, is there the potential for nationally significant energy conservation?

(2) If we do have a problem what is the quantitative model, including both the history and the current state of the system?

(3) What options are available? Here we include economic, social, political, and behavioral constraints.

(4) How do we select a strategy; that is, how do we optimize?

(5) How can the decision be implemented - e.g., within the procedures and protocols of government?

When we raise these questions with regard to the CAFE standards, we immediately face the question of what the average means in energy terms? For example, 50 mpg specification would save a certain quantity of oil compared to today's 20 mpg. Ninety percent of that saving is realized by just over 70% of the change, however, so we "pay" more and more for successive improvements.

Furthermore, the mileage standards can not be established without simultaneously considering the other performance characteristics: those on emission, crashworthiness, and customer satisfaction. This broadened view of the problem elicits inquiry into how the mileage is actually measured by the EPA. Is there strong correlation between performance on the standard test run and mileage in driving by actual motorists?

The problem is facinating because it is drawn from the real world, it looks to the future, it involves basic concepts of engineering (for example, in the man-machine interaction), it raises important political and economic questions, and, finally, the simplistic answers are easily shown to be valueless. In the ultimate decision, we have to make trade-offs based on our values.

Amniocentesis

The second example involves the question of whether obstetricians should urge (or in the extreme, government should encourage) anmiocentesis for expectant mothers over 35. Is this a decision we should make for the individual, either through legislation or coercion?

The problem is much more complex than appears initially, since several factors must be considered:

Safety of the ultrasonic pictures during the procedure.

Safety of the anmiocentesis, proper.

Number of false positive and false negative results.

Timing, with the test done in the 16th week, a retest in the 20th week, and a final positive result not available until the 24th week.

Probability of prospective mother deciding against abortion even if test results are positive (a decision strengthened by her having felt life by the 24th week).

Once the quantitative parameters are established (with the science background involved in ultrasonics, for example), the problem is beautifully presented in terms of a decision tree. The complexity of the multi-stage decision emphasizes the great difficulty in obtaining truly "informed consent" before the procedure is started.

Program for future

These two examples merely illustrate the basic characteristics of the courses: the emphasis on applied science and engineering, the concern with topics viewed by the students as important, and the procedure of starting

and motivating through the case study or specific problem. As we look to the possible expansion of such courses to other institutions, we seem to be faced above all with a severe shortage of textbooks -- not poorly related collections of articles, but unified presentations.

Fortunately, the situation is gradually improving, the student interest is exceptionally high as we enter the 1980's, and government and private agencies interested in higher education are recognizing the importance of education for technological literacy.

John Truxal

* * *

A DESIGN FOR A GENERAL TECHNOLOGY COURSE

One reason for this gathering is the belief, perhaps naive, that people who are scientifically and technologically literate will aid our society in making national decisions in the trying years ahead. Amongst faculty, it is generally agreed that the discipline of the study of a science and its predictive ability is one necessary ingredient of a liberal education.

In the early 1970's, a few of us had our try at implementing both of these concerns spurred by the miserly enrollments in engineering and physical science major programs. This state of affairs induced by economic downturn, an irrational national science policy, and the implications of student demography on graduate education, was exacerbated by the absence of any general science requirement. While the courses necessary for the premedical program were over-subscribed, most of the science faculty taught a delightfully few students. In hindsight, looking over the numbers, the faculty was not even supplying a liberal education. Nearly 40% of each class graduated with but one or less courses in the sciences or mathematics! In the 60's, when the strict course requirements were placed with broad guidelines (guidelines with loopholes), some individuals did attempt innovations. There was "Science for the Nonscientist," which in all honesty met with failure. This failure was induced more often than not by a too strident criticism by colleagues that these courses were not professional, or were insufficiently rigorous. Thus, institutional rewards for these brave individuals were nonexistent. In my mind's eye, there was also a deterioration of the quality of teaching. By this time, lecture demonstrations had all but disappeared from introductory physics and chemistry courses, thus removing another channel of communication with the student. For now the fun, beauty,

and indeed necessity of experiment, upon which predictive science is built, was relegated to the verbal and the two-dimensionality of the text book and chalk board.

In the department of Engineering and Applied Science, a few faculty whose emotional bond was that of recent tenure and whose offspring were starting their college years, designed a pair of nonprofessional courses on current science and technology. The first of these is entitled Perspectives on Technology. I cite the 1980 course description: "An examination of the impact of technology on modern society that presents underlying science, current applications, and future promise and problems will be presented by six faculty members. Students select any three of six topics for course credit." This format has proved to be an essential ingredient for the success of the course. One now asks a faculty member to distill his professional and research interests into ten hours of lectures and demonstrations. This proves to be a stimulating challenge which is not overly demanding of total time, but an intensive four weeks is required generally beyond an individual's standard teaching load. This format also insures continuity year-to-year, allowing the rotation of many faculty members into the course, countering the problem of faculty leaves, replacements, and resignations. Ten hours are sufficient to convey with rigor the applicable fundaments of the science, as well as the status of technology. Due to the student's exposure to three subjects, he sees how scientific and engineering methods are applied to various technologies, perceives the limits set by nature on some of man's diverse activities, and observes the contrasting styles practiced by individuals and their discipline.

As a spring course since its inception in 1974, nineteen faculty members have participated, including four from other departments of the university. The enrollment has been consistently in excess of 200.

It might be instructive to consider the marketing technique we used in 1974, which was of great concern to us at the time. We sent to each undergraduate an announcement with a preamble here cited:

> Energy crisis...environment...the plastic age... mass communications...sound reproduction...medical revolutions. These catch-words signify technologies which affect the human condition daily. Not every educated person can, or should, direct his creative energies into science or technology. But, should someone consider himself properly educated in 1974 without serious intellectual exposure to such topics?
>
> A group of Yale University scientists, engineers, and physicians have assembled six four-week mini-courses to be offered in the Spring Term 1974 as:
>
> EAS 17b, PERSPECTIVES ON TECHNOLOGY.

Students select three of the six topics offered. There are no science or mathematics prerequisites. This course has no lab, but live demonstrations will be widely used. The main objective of these glimpses into technology is to familiarize students with the scientific background, present status, and future potential (and harm) of several crucial technologies. Each lecturer is involved professionally with his topic. Nature's limitation to the expansion of a given technology will be distinguished, whenever possible, from man's limitations.

This stimulated a first-day attendance of nearly 300 students, followed by extensive reporting on our "unique marketing" in the Yale Daily News. These days such shrillness is unnecessary.

I have iterated our method of stimulating the productive research faculty into sharing their experience and knowledge of nature and technology with non-science undergraduates in ways which are no longer onerous to them. The environment and politics of each institution are different yet it is with our sharing of these experiences that devices can be designed to increase our impact upon people.

Robert Wheeler

* * *

BASIC SCIENCE AND THE LIBERAL ARTS

Concerning the relevancy of basic science to technological development one might quote Sir Cyril Hinshelwood who put it somewhat like this: If an ancient potentate had offered a rich reward to someone who could make significant progress toward sending messages across thousands of miles in less than a second, the reward would not have been won. However, if he had offered a reward to someone who could explain to him the nature of the attraction between an amber rod and a piece of silk with which it has been rubbed, he would have been setting his subjects on the direct road to high speed communication. The search for fundamental understanding of the phenomena of our world and the Universe of which it is a part is the direct road to major technological achievements. It is essential for our continued improvement of the quality of life that this search for understanding be encouraged, not only because of its certain contribution to technology, but also because understanding of our environment is the right and privilege of human beings whose lives are enriched by such awareness.

Science, like art, drama, and music, is a creative human activity. Scientists assemble the fragments of many isolated small discoveries to create the discovery of a general principle which leads to understanding, or indeed is what we mean by understanding.

Elizabeth Wood

AN AGENDA FOR ACTION

The conference is focused on four types of continuation activities. First was the sharpening of ideas about what is currently taught well and how it is taught. The preceding pages state in as brief a space possible the diversity of successful approaches. As a recent Carnegie Council report affirms, there are about 3,000 futures for U.S. colleges and universities. In the development of science and technology curricula there will probably be similar variety of adaptation to local circumstances.

Similarities between programs lie more in the institutional support (or lack of it) for them. Whether what is involved is a complicated relationship between off-campus and on-campus resources or simply released time for one faculty member, faculty and administration need to be convinced that such programs contribute to professional development of instructors, are intellectually as rigorous as the more clearly disciplinary offerings, and are, as a result, worthy of institutional support.

Methods for achieving such a radical revision of usual reward systems should be addressed at a follow-up workshops and conferences. Several formats were discussed. Chief among them were dissemination conferences and skills development ("retooling") workshops. The former will address the question "what are other institutions similar to mine and in similar environments doing." More than a show and tell, such gatherings will be task and outcome oriented, so that participants can adapt methods successful in contexts similar to their own. Program form will range from interdisciplinary on-campus arrangements to successful cooperation with mass media, museums, industry programs, and community based organizations.

Skills development workshops must be more comprehensive than the short-course approach. Skills require upgrading not only in intellectual content, but also in the application of such content to various instructional modes, to research interests, to the development of skills marketable off-campus, and to the sense of personal and professional development of the individual participant.

The regional conferences will also examine dissemination activities. Local and regional associations are useful agents for both dissemination and skills development. In addition, cooperative arrangements can be developed with local media. As a first step, the information presented at the conference reported here is being assembled for inclusion in the (ERIC) Clearinghouse under four categories: Information Clearinghouse, Conferences, Programs and Instructional Material, and Public Policy Papers. More interactive modes of storage are currently being explored as are linkages to other databases. In order to keep abreast of new (and old) developments,

the Association of American Colleges has developed a questionnaire asking for information on the four categories mentioned above. The new data will be continually added to the ERIC system.

None of these activities can proceed far without additional funding. The current strategy is to secure grants on a conference by conference basis. More systematic fund-raising is envisioned as a consequence of regional conference discussions. Involvement of potential funding sources in the planning and program of regional meetings is one way to enlarge this base. Another is to develop cooperative relationships with industry in on-campus and off-campus program development.

For the most part, however, the design and implementation of new instruction in this area requires drawing upon the same enthusiasm and creativity witnessed at the conference. The curriculum we are describing here lends itself well to building new cooperative arrangements. Such arrangements provide great fiscal and intellectual credibility for new instructional development.

CONFERENCE FACULTY

Richard Berendzen, The American University
Roger Blobaum, Blobaum and Associates
John Clayton, Organization of American States
Helen Conover, Playback Associates
William Eilers, Agency for International Development
Edward Friedman, Stevens Institute of Technology
Daniel Greenberg, Science and Government Report
Earl Hanson, Wesleyan University
Anna Harrison, Mt. Holyoke College
George Hazzard, Worcester Polytechnic Institute
Brooke Hindle, Smithsonian Institution
Harold Hodgkinson, National Training Laboratories
Donald Honicky, AT&T
Patricia Joffee, MIT
Edward Kormondy, University of Southern Maine
Thomas Liao, SUNY at Stony Brook
Arthur Livermore, American Association for the Advancement of Science
Ward Morehouse, Council for International Studies and Programs
Dorothy Nelkin, Cornell University
Ted Owens, AT International
Rustum Roy, The Pennsylvania State University
Lance Schachterle, Worcester Polytechnic Institute
Robert Semper, San Francisco Exploratorium
Joseph Szyliowicz, University of Denver
Michael Templeton, Association of Science Technology Centers
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